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To Link or not to Link? Empirical Guidance to the Design of Nonlinear Text Systems

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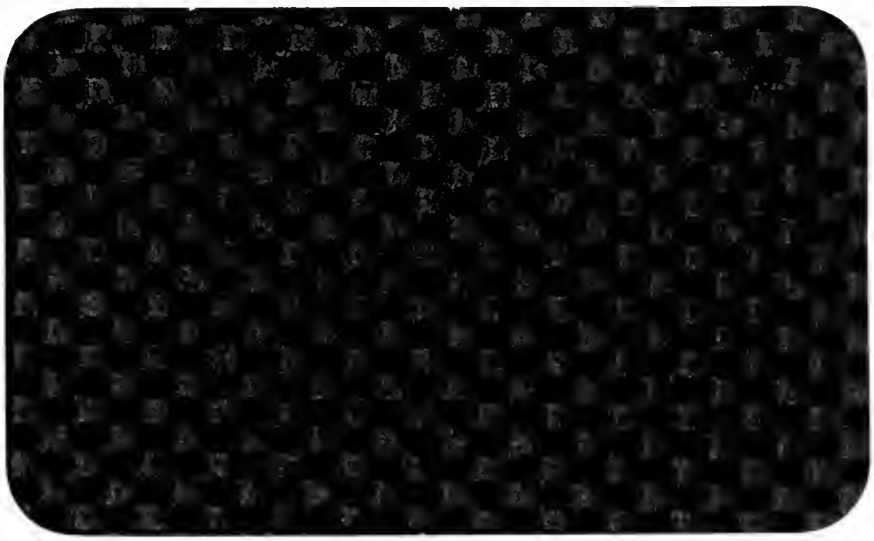

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TO LINK OR NOT TO LINK? EMPIRICAL GUIDANCE TO THE DESIGN OF NONLINEAR TEXT SYSTEMS

by

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1. Introduction

This study uses controlled experimentation and protocol analysis to 1)compare linked and non-linked versions of the NetBook data model in order to contribute to the current debate over user categorization errors, searching via links and getting lost in nonlinear systems, and 2)to evaluate the effectiveness of the NetBook knowledge exploration system [S85,S86].

The NetBook model is based on relational databases augmented with hierarchies on domains and on hypertext. The user of information accesses sets of text fragments through menu selection among properties and values and then explores other fragments through hypertext links. The system attempts to linearize the set of fragments chosen by a query in a rational way, e.g. prerequisite information first.

1.1. Motivations for Experimental Study

In recent years, the experimental study of human performance in using computer and information systems has been recognized as a necessary accompaniment to the design and development of these systems. Particular emphasis has been placed upon query facility usage and interface design, both in evaluation research on particular systems and comparative research between systems or models of proposed systems [Shn80]. Although simulations have been used (paper-and-pencil tests, for example), workers such as Norman believe that it is essential to test ideas relevant to computer-human interaction within an actual working environment, rather than a simulation [No83].

Shneiderman suggests that the use of controlled experimentation is particularly appropriate in the database and information systems area, since the potential user's background is very different from that of the programmer or designer [Shn80]. Because the potential user is likely to be an infrequent and unskilled user of the system, an interface appropriate for a more expert user might be useless with a novice.

Shneiderman considers the more anecdotal protocol analysis to be another appropriate experimental tool. Card, Moran and Newell use protocol analysis to model the computer user within an information-processing psychology framework [CMN83]. Their application is text editors.

Chapanis, Anderson and Licklider suggest some of the dependent variables which can be used to measure effectiveness: how easy it is to learn to use a system, the extent to which tasks can be performed quickly, and the extent to which errors are likely to be made [CAL83].

1.2 Data Organization, User Interface and User Errors

The present study was concerned with two related aspects of information systems which affect effectiveness - how the data are organized in the database and the ease-of-use of the interface.

Canas et al. studied organization in a manual filing cabinet system in which they found a retrieval success rate of over 90% [CSC85]. The authors suggest that if we understand the way people classify and search for information in manual systems, we would be able to design better automated systems. Studies of electronic retrieval systems generally show a lower rate of successful retrieval [FV80].

Retrieval rates may be lower because users opt to use only basic searching features of an

automated system in which they are unskilled. Weyer examined the effect of the interface on searching strategies using a dynamic book, Dynabook, with a high-school level world history text as his database [We82]. He compared the dynamic version to two others- one in paper and a second that was electronic but not dynamic. In the dynamic book, instead of accessing by a one-level subject index and page numbers as in the non- dynamic, electronic book, accessing was through an expanded three-level outline of chapters, sections and subsections, along with mechanisms for matching patterns.

Weyer found that students learned elementary features of the system quickly, but the more elaborate features were seldom used. Although students preferred the two electronic forms of the book, the non-dynamic electronic book was faster to use. Answer correctness did not vary between conditions.

Many accessible databases for novice users are menu driven, as is NetBook. Otherwise, the user may experience what Landauer et al. call "novice freakout" [LDGF82]. Indeed, "novice freakout" may occur even in a menu-driven system if the menu is not clear to the user, or if the data in the database are poorly arranged from the user's point of view. As Walker points out, it is essential that the user have a reasonable amount of knowledge about how the information in the database is organized [W81]. Even with that knowledge, however, if the organization of the database is different from what the user expects, there may still be problems.

Landauer et al. point out that efficient system processing generally takes priority over other consideration in arranging data in a database. The logical connections in the user's mind may not match the connections necessary for an efficient system because people seldom organize information in a deeply nested hierarchy. Also, people differ in their categorizations [DL84]. Studies of videotext systems support the contentions of Dumais and Landauer. In an experimental study of the Prestel viewdata service, a database containing information about a range of topics - news, financial data and other reference materials - Frankhuizen and Vrins asked subjects to find answers to various questions, such as "What language is spoken in Ethiopia?" Almost half of the questions were not answered correctly [FV80]. In addition, in almost half of the questions, subjects did not find the answer using their initial strategy, but started over again from the beginning one or more times. In terms of precision of retrieval, successful locations of answers were not efficient. On average, twice as many pages were retrieved as was necessary. Frankhuizen and Vrins attribute these problems to category overlap and ambiguities in category naming. One videotext system, for example, would decompose "night life" in its hierarchies into supposedly disjoint categories including "attractions" and "entertainment". The problems with categorization in a single hierarchy suggest that a knowledge exploration system should support multiple overlapping hierarchies, a decision taken in NetBook.

An additional categorization problem that any system will have is suggested by Walker [W81]. In an information system, new developments in a body of knowledge might necessitate adding new entries to the index listing, but it will be difficult to reclassify the older text to reflect the changes. The example that Dumais and Landauer use is that if you want to locate computer science books, they are classified under the category "generalities" in the Dewey Decimal System.

1.3. Information Links

One proposal for overcoming categorization problems and false starts has been to use links between information fragments. In Bush's classic article on the future of information systems, he suggested that because the index categories by which information can be stored in

a system and the mental processes by which a human classifies information are very different, selection by indexing is not optimal [Bu45]. Rather, since the human mind operates in an essentially nonlinear way by association, selection by association is a better strategy, if it can be mechanized. Bush called this process of linking many items of information "building a trail", ideally with the capacity to branch onto side trails of subtopics, through the available texts.

These ideas are consistent with theories in modern psychology. Take, for example, the theory of "spreading activation". The basic idea is that each person has a mental dictionary with words linked to other words by associated meanings, associated sounds, or associated grammars, forming a sort of spider web of points. Speaking is an activation of points on this web. Each word selected activates an alternate path through the web [M87].

Yankelovich and Meyrowitz say that computers, compared to books, are particularly suited to helping users create connectivity, i.e. webs of related information [YM85]. In a book, links are usually created only through footnotes or through notes that the user writes in the margins. With electronic media, organization of materials can be more flexible.

Links between fragments of information may also have their drawbacks. Yankelovich and Meyrowitz believe that a disadvantage to electronic information systems is that they do not inform users where they are in a document. Following a trail of links may exacerbate this problem [N79,YM85]. This is in contrast to a book, in which the reader can tell if he is halfway through or someplace else. Because an electronic book is nonlinear, what is the middle for one user might be the beginning for another user. Therefore, someone following link after link can feel very disoriented. For example, in the FRESS hypertext document system at Brown University, users often found it difficult to remember where they were in the text. Nevertheless, virtually all researchers feel strongly that any electronic document system should include tools for connectivity.

Several nonlinear text systems which make use of links have been described, the largest being ZOG with 20,000 frames [AM84,E84,F84,H80,L85,Ne84,S85,S86,SH87,TW86]. Many different design features have been employed. In Fogg's The Living in a Database System, for example, users from inside an entity-relationship tuple can answer queries by examining the database from that tuple's perspectives. Fogg bases his interface on the ideas of Cattell who describes an interface in which each frame contains a list of adjacent nodes for the user to explore [C80]. Herot's spatial data management system (SDMS) presents information graphically.

Shneiderman describes a nonlinear system that works via embedded menus - The Interactive Encyclopedia System (TIES). Users can select topics through words that are highlighted in the text and immediately go to view an article on the selected topic. This is in contrast to the more traditional separation of text reading from menu category selection. When embedded menus are compared to more traditional menus, subjects complete more questions more quickly with embedded menus and also jump more frequently among articles.

2. Our Experiment

A database consisting of text fragments was created, using the authoring and editing facilities of NetBook [S85,S86]. The text fragments were taken largely from two chapters of an introductory sociology text. Some additions and modifications were made where it was thought that information needed to be updated or elaborated upon.

Fragments were broken down by ten relevant properties and appropriate values.

(Properties correspond to slots in frame-based systems or attributes in database systems.) Subvalues, or hierarchies within property domains, were not employed, because we wanted to use only the simplest mechanisms in NetBook.

Properties and values were chosen in such a way as to make it possible to obtain the same information through more than one query. Properties and values were also chosen to be orthogonal as much as possible, i.e. choosing a value of one property should not restrict the possible values of other properties.

The links between fragments included example, critique, counter-argument, compared-with, and continuation (linking a fragment to the following one in the original text). Continuation links were also used by NetBook as input to a presentation algorithm which presented adjacent fragments with the properties and values queried in linear order. The continuation order was not violated, unless it was necessary to avoid violating an example link or one of the other types of links. The notion of trying to present the fragments returned by a query in the same order as they appear in the original text may strike nonlinear text adherents as blasphemy, but that heuristic seemed reasonable to us, all else being equal.

Subjects were undergraduate volunteers from The New York Institute of Technology. Fifty were randomly assigned to one of two groups and run individually. Subjects in both groups were permitted to use properties and values to specify text fragments. The difference came about in the use of hypertext links.

1)Links group. Participants were told about the links option and encouraged to use it.
2)No-Links group. Participants were told that the links option on their screen menu could not be used.

An additional ten subjects were randomly assigned to a third group, for the purpose of making baseline comparisons of speed and accuracy. This group used a paper copy of the text and its Table of Contents to search for information (Paper Text group). These subjects were also run individually. The groups had no significant differences in mean grade-point average and had an equal amount of exposure to sociology.

Each subject from group 1 and group 2 was exposed to a 20 minute group introduction to the database and the query system, followed by an individual review and demonstration. In the individual review, subjects were given a sheet listing the properties and values used to organize text fragments. The sheet also contained a brief outline of how to use the menu system to form queries. Subjects were given five minutes to review this sheet and told that they could also keep it in front of them to refer to as the session proceeded. They were also encouraged to ask questions about the procedure at this time.

After each subject in group 1 and group 2 (the electronic groups) reviewed the database organization and query procedure outline, the subject underwent a hands-on demonstration.

Subjects were then told to locate, as fast as they could, the information requested in the five questions given them. The presentation order of the questions was rotated in order to measure practice effects.

Each search was timed from the point at which the question was presented to the point at which the subject began to record the answer on the answer sheet. In addition, protocols were collected of each subject's menu choices throughout each query (see Figures 1 and 2 for a sample protocol sheet and NetBook's menu choices). If the subject was unable to complete all five queries within 50 minutes, the session was terminated at that point.

Figure 1. Sample Protocol Sheet

Name:_____BM______
Group:__No_Links____
Number of 1st Question in this Permutation:___1__

	Time	Queries made:
Q. 1)	17'50"	

start query
start query
specify or change properties
  add spec-theorist.Marx
  add spec-class category.gen. comments
  display text
  remove spec-class cat.gen. comments
  display text

2) 6'05"

start query
specify or change properties
  add spec-location.India
  add spec-type of strat.caste
  display text

3) 2'49"

start query
specify or change properties
  add spec-location.Japan
  add spec-social mobility.intergen'l
  display text

4) 6'18"

start query
specify or change properties
  add spec-measurement.gen. comments
  add spec-location-U.S.
  remove spec-measurement.gen. comments
  add spec-empirical study.Warner & Lunt
  add spec-type of strat.class
  display text
  display spec
  remove spec-type of strat.class
  display text

5) 6'36"

start query
specify or change properties
  add spec-location.U.S.
  add spec-class category.upper
  display text

3. Results

3.1. Use of Links

Links-group subjects were not all equally inclined to use them. Figure 3 shows the number of subjects who used the hypertext capabilities of the system, broken down by question.

Some questions apparently encouraged the use of links more than others did. Questions #3 and #4 were fairly accessible without the use of links, so most subjects searched for an answer through properties and values. Informal questioning of subjects who did not use links, or who used them very sparingly revealed that some subjects felt overwhelmed by the hypertext menu, despite a review of the menu choices as part of the initial introduction of subjects to the system.

Figure 4 shows the frequencies of hypertext use in queries in the Links group. Three

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Figure 2. NetBook User Menus (version without editing facilities)

Main Menu
1.start new query
2.specify or change properties of a query
3.list current queries
4.display text associated with a query
5.quit

Specify or Change Properties Menu
1.add specification
2.list possible specifications
3.remove specification
4.display current specifications
5.display text associated with a query
6.return to previous menu

Hypertext Menu
1.return to reading the next fragment specified by the query
2.mark place
3.return to last mark
4.go back 1 step
5.repeat text
6.save for printing
7.create a new query with this fragment's properties
8.[menu continues here with a list of link options]

.

.

.

---

subjects would not use the hypertext system at all. Other subjects used it for between one and three queries. Subjects who did not use links, although they were available, were grouped with those in the No-Links group for analyses where applicable.

NetBook's links were sufficient to locate information fairly directly with an inadequately specified or incompletely specified query. For example, in the following protocol excerpt, for Question #5 ("The percent of the national wealth that is owned by the richest fifth of Americans."), the subject has specified only that she wishes to see all text related to wealth:

```
start query
specify or change properties
    add spec.-form of class inequality.wealth
    display text - hypertext - compared with
```

Although it took the subject 788 seconds to complete the query, somewhat more than average for subjects in the No-Links group, she needed to follow only one link to obtain the answer. Most of the time the subject spent completing the query was spent hesitating about what to do, rather than doing anything with the system that took a substantial amount of time.

On the other hand, a subject with a query that was not fully specified, or inappropriate, could also become totally lost in the hypertext feature of NetBook. In the following protocol excerpt, the subject spent the entire fifty minutes attempting to locate the answer to Question #1 ("The name of Marx's book, in which he begins to present his ideas on social class."). She never completed the query, but rather went back and forth over the same text links:

```
start query
specify or change properties
    add spec.-theorist.Marx
    display text - hypertext - continuation - go
      back one step - go back one step
    list possible spec.-properties
    add spec.-class category.general comments
    add spec.-theorist.Marx
    list possible specs.-properties
    add spec.-theory.conflict
    display text - hypertext - continuation -
      continuation - go back one step - create a
      new query - exit
    display text - hypertext - counter-argument -
      counter-argument - critique - continuation -
     critique - create a new query - mark place -
     exit
start query
specify or change properties
    list possible specs.-properties
    add spec.-location.Continental Europe
    add spec.theorist.Marx
    display text
    display current specifications
    list possible specs.-return
    add spec.-type of stratification.class
    display text - hypertext - continuation -
```

continuation - continuation - continuation
- mark place - create a new query - see
text of which this is critique - see
text of which this is critique -
continuation - continuation - go back one
step - go back one step - example - go
back one step - exit
add spec.-theory.conflict
(subject used up all her time at this point)

The protocol excerpt of the following subject illustrates the way a subject may use links to locate information with a poorly specified query. Completion of this query for question #4 took 737 seconds. Instead of using the property "empirical study" with the value "Warner and Lunt" and the property "class category" with the value "general comments" in the query, the subject chose to approach her task by guessing at a correct measurement method. She begins by choosing an incorrect method, removes it, chooses another incorrect specification, removes it, adds one that provides only general comments and from there follows links until finding the correct answer:

start query
specify or change properties
list possible specs.return
display text
add spec.-measurement method.subjective
display text
remove spec.-measurement method.subjective

Figure 3. Use of Links by Question Number

Question #	Used Hypertext	Did Not Use Hypertext
1	15	3
2	10	6
3	3	13
4	5	15
5	10	9

Figure 4. Frequency of Hypertext Use

No. of Queries Using Hypertext	Frequency
0	3
1	7
2	9
3	6

(average no. of completed queries = 3.28)

add spec.-measurement method.objective
list possible specs.-values.location
display text
remove spec.-measurement method.objective
add spec.-measurement meth.general comments
list possible spec.-values.measurement meth.
display current specifications
display text - hypertext - continuation

This can be compared to the following protocol excerpt for question #1, in which the subject uses links not to locate the correct answer, but to realize that he has specified his query incorrectly. He then returns to the menu to adjust his specification and finds the answer. This query took 533 seconds to complete:

start query
specify or change properties
add spec.-theorist.Marx
add spec.-location.Soviet Union
display text - hypertext - continuation - exit
remove spec.-location.Soviet Union
add spec.-type of stratification.class
display text

3.2. Number of Links

Figure 5 shows the average number of links used for each question by those subjects in the Links group that used the system's hypertext capabilities. The maximum number of links followed on any query was 28.

There was a statistically significant negative correlation between the average number of links a subject followed and the total number of queries completed ($r = -.74$, $p = 0.001$). Unsurprisingly, there was also a statistically significant negative correlation between the average number of links a subject followed and the total number of correct queries ($r = -.73$, $p = 0.001$). The number of links followed slowed down query completion time for subjects in the Links group.

3.3. Completion Time

Comparisons were also made of the average time it took subjects to complete each query.

Figure 5. Average Number of Links Used by Question

Question #	Mean	Standard Deviation
1	3.933	7.235
2	4.500	5.276
3	3.000	3.464
4	4.800	4.324
5	3.100	3.143

In four out of five questions, subjects in the Links group took the longest amount of time to complete the query, followed by subjects in the No-Links group, followed by subjects in the Text group. In one of the questions (Question #3 - "The intergenerational mobility rate in Japan."), the Links group took longer on average than the No-Links group, but the Text group took longest of all. Since the information requested was not readily obtainable from the Table of Contents in the paper text version, but required more searching of related topics in the paper text, this was understandable.

Figure 6 lists the average number of queries completed by each group and Figure 7 lists the means and standard deviations for completion time for each group for each question. One-way analyses of variance revealed statistically significant differences among groups. T-tests on the two electronic groups revealed significant differences for three of the five questions.

3.4 Specifications

Although the larger average number of specifications by subjects in the Links group was not statistically significant, over both groups there was a significant positive correlation between the average number of specifications used for a query and the average number of seconds spent obtaining the answer to a query. Perhaps with a faster system, this relationship would not hold, but in this particular version of NetBook, there is significant overhead to forming highly specific queries. The correlation between average time per query and average number of specifications used is .84 ($p = 0.001$).

As an illustration of this overhead, contrast the following two protocol excerpts for question #5 from different subjects in the No-Links group:

start query
specify or change properties
    add spec.-location.United States
    add spec.-class category.upper
    display text
(time = 396 seconds)

and

start query
start query
specify or change properties
    add spec.-form of class inequality.wealth

Figure 6. Average Number of Queries Completed by Group

Group	Mean	Standard Deviation
Text	5.00	0.0
No-Links	4.25	1.29
Links	3.23	1.48

($F = 7.784$, $n = 60$, $p = 0.0010$)

Figure 7. Average Seconds to Complete Each Query

Question #	Group	Mean	Standard Deviation
1	Text	508.80	493.56
	No-Links	570.55	526.05
	Links	1125.56	837.28

($F = 4.306$, $n = 48$, $p = 0.0194$)

Question #	Group	Mean	Standard Deviation
2	Text	47.70	15.10
	No-Links	397.92	289.37
	Links	877.14	512.36

($F = 17.810$, $n = 48$, $p = 0.0000$)

Question #	Group	Mean	Standard Deviation
3	Text	726.00	434.39
	No-Links	308.08	171.28
	Links	493.00	560.15

($F = 5.141$, $n = 50$, $p = 0.0096$)

Question #	Group	Mean	Standard Deviation
4	Text	109.10	18.47
	No-Links	581.70	502.98
	Links	703.94	515.19

($F = 5.553$, $n = 54$, $p = 0.0066$)

Question #	Group	Mean	Standard Deviation
5	Text	52.40	7.03
	No-Links	616.00	667.49
	Links	803.59	413.66

($F = 6.675$, $n = 52$, $p = 0.0027$)

display text
(time = 299 seconds)

It is clear from the above two excerpts from subject protocols that both subjects understood the data retrieval system. Nevertheless, neither subject used a full specification to find the answer to the question ("The percent of the national wealth that is owned by the richest fifth of Americans.") The first subject narrowed down the range of material to be searched more, but spent so much more time doing so, that retrieving the answer actually took more time - roughly one-third more.

Some subjects continued to make specifications when no longer necessary, or made incorrect specifications ("false starts") and then had to begin again. The following protocol excerpt illustrates the use of inappropriate continued specification. Because the user became impatient each time she asked to see text, she narrowed down the field of information requested too severely. To complete this query for question #1 took 1770 seconds:

start query
specify or change properties
    add spec.-theorist.Marx
    display text
    add spec.-class cat.general comments
    add spec.-theorist.Marx
    display text
    add spec.-type of stratification.class
    display text
    add spec.-theory.conflict
    display text
    add spec.-location.Great Britain
    display text
    display current specifications
    remove spec.-theory.conflict
    display current specifications
    remove spec.- location.Great Britain
    display current specifications
    add spec.-degree of indust.industrial
    display text
    remove spec.-degree of indust.industrial
    display current specifications
    add spec.-theorist.Marx
start query
specify or change properties
    add spec.-theorist.Marx
    display text
    add spec. theory.conflict
    display text

In the above excerpt, the subject decides to begin over again with a considerably scaled down query. Her original specifications were all not entirely inappropriate and two are re-used.

3.5. Practice Effects

As mentioned above, the order in which questions were presented to subjects was rotated in all groups in order to measure practice effects. Figure 8 shows mean query completion times for all groups combined for first through fifth queries. Subjects who began a query, but did not complete it because they ran out of time are included. There appears to be a trend towards faster completion of later queries.

However, since the Text group completed all queries, while only a portion of both electronic groups did so, the faster responses of the Text group are overrepresented in the latter queries. Therefore, mean completion times for first through fifth queries were broken down by group and query for those subjects who had completed all five queries. The mean query completion times are shown in Figure 9. They show practice effects for both No-Links and Links subjects through the fourth query completed. Completion times increase for the fifth query, perhaps as a result of fatigue.

3.6. Gender, Attitudinal and Experiential Measures

Figure 8. Mean Query Completion Times by Query Order

Query Order	Number	Mean	Standard Deviation
First	60	827.57	688.99
Second	57	514.05	483.10
Third	53	518.43	477.49
Fourth	44	391.18	438.93
Fifth	38	402.97	355.73

Figure 9. Mean Completion Times in Seconds by Group and Query order for Subjects Completing 5 Queries

Query Number	Group	Mean	Standard Deviation
1	Text	408.90	576.28
	No-Links	466.43	234.31
	Links	847.38	282.01

($F = 3.773$, $n = 36$, $p = 0.0335$)

Query Number	Group	Mean	Standard Deviation
2	Text	206.70	265.54
	No-Links	389.83	166.09
	Links	543.88	350.13

($F = 4.334$, $n = 36$, $p = 0.0213$)

Query Number	Group	Mean	Standard Deviation
3	Text	257.90	304.03
	No-Links	335.89	195.34
	Links	371.38	199.67

($F = 0.601$, $n = 36$, $p = 0.5543$)

Query Number	Group	Mean	Standard Deviation
4	Text	376.90	547.20
	No-Links	280.33	88.79
	Links	300.25	152.93

($F = 0.338$, $n = 36$, $p = 0.7158$)

Query Number	Group	Mean	Standard Deviation
5	Text	213.60	219.62
	No-Links	311.78	135.99
	Links	567.00	302.73

($F = 6.967$, $n = 36$, $p = 0.0030$)

There were a total of 38 males and 22 females participating in the study. Data were broken down by gender, but there were no significant differences between males and females.

Attitudinal and experiential measures did not vary according to whether subjects were in the No-Links or Links groups. Eighty-eight percent of these subjects did not have much previous experience with databases and could thus be considered comparable on this dimension with naive or occasional users in other studies. Eighty percent of these subjects had also a generally favorable attitude towards computers, finding them at least somewhat enjoyable. There was no relationship between attitude or experience and performance.

4. Summary and Recommendations

Some questions encouraged the use of links more than did others and some subjects in the Links group were more likely to use the hypertext menu than were others. This finding is consistent with that of Weyer who found that students learned simple features of Dynabook quickly, but did not use its more elaborate features [We82].

Subjects in the No-Links group completed significantly more queries than did those who used links. We believe that this is not merely a result of confusion from being offered the choice of several alternatives, because subjects who had the option to use hypertext but did not do so performed comparably to those who did not have the option available.

Comparisons with a group that used more conventional text for knowledge exploration revealed that they performed best of all groups when the Table of Contents was enough to locate the desired information. When the Table of Contents was not enough, the Text group performed poorest of the three groups. The advantage of text under certain circumstances is consistent with research reported by Shneiderman [Shn87]. Reading from screens has been found to be roughly thirty percent slower than reading from paper text.

There was a statistically significant positive correlation between the average number of specifications used for a query and the average number of seconds spent obtaining the answer to a query. An excessive number of specifications generally indicated an inability to properly use the system to retrieve the desired information.

There was some evidence of practice effects in the data in the two NetBook groups through the fourth query completed. Fatigue may have increased completion time for the fifth query. There was no evidence of practice effects in the Text group, but none was expected, since users of text have had plenty of prior practice and are actually expert users of the medium, rather than novices as was the case with both electronic groups.

4.1. Recommendations on the Use of Links

One of the reasons why users in a particular system have difficulty using links is that they do not always have all of the information that they need or not all of it is salient. As Landauer et al. have pointed out, users may receive only a small amount of local detail at any one time, i.e. what a fragment's links look like, whereas more global information on the overall structure of the database and its paths of links might be more useful [LDGF82]. This is consistent with subjects' reactions to NetBook. Some subjects expressed the fear that using links would get them too far afield. They felt it was quicker to search through the fragments called up by properties and values (which are global information) rather than to follow links through "unknown territory".

Although using links may in fact take longer and may result in a higher number of naive users getting lost, designers of information systems agree that it is highly desirable that a system have this feature, particularly when properties and values don't fit what the user has in mind.

Links, however, could possibly be improved in one of the following ways:

1) A facility for allowing the user to see the properties and values of a specific link target could be helpful. With this feature. those who felt reasonably confident about their original query specifications and did not want to wander off into a different topic might not choose a particularly link. On the other hand, users who felt that the properties and values of the link fragment were more appropriate than their original specifications could then modify the direction of their search. In the present study, users of links sometimes wandered out of their specification set. They were not only uncertain about whether they had actually left their original specification set, but were also uncertain about how to get back to their original specifications or even whether it was desirable to get back to the original specification set. These difficulties could be alleviated somewhat with the proposed facility.

2) A "fisheye" view of the database, as proposed by Furnas, could be presented in a small window on the user's screen [Fu83]. Users would have a simultaneous view of both the parts of the database structure near their current focus of interest (e.g. a fragment's links) and a view of the higher structure of the database (e.g. major attribute headings and where a fragment specification fits into that overall structure). This may be a useful way to keep people oriented in an information system like NetBook in which the structure is too large for naive users to deal with all at one time. In the present study, some users of the links reported feeling overwhelmed by the attempt to keep themselves oriented in the text, often just giving up and randomly exploring. Orientation aids in the system would help prevent random exploring in situations where a directed search to find specific information is more appropriate.

3) Embedding links directly into text. as Shneiderman or Brown describe, or displaying link names at the bottom of the screen, while a text fragment is displayed, might be more efficient means for entering into a linked path than requesting a separate hypertext menu as is now done in NetBook [B86a,B86b,Shn87]. Some users in the present study seemed to have difficulty moving between the specification menu and the hypertext menu. Having all choices displayed on the screen at once would eliminate this difficulty.

In addition, the way the data is organized in a text database may need to be examined experimentally. Categorization of attributes and values of text segments should perhaps initially be done by a group of naive users similar to the users of the system. The optimum number of properties and/or values should also be examined experimentally. In addition, the optimum amount of hierarchical structure could be explored. This may vary from application to application.

Finally, whether or not links are desirable may depend upon how a system is to be used. In information systems, undirected explorations without an answer to a specific question in mind are different from directed searches for a specific piece of information. Links may be more useful when searches are undirected. A person who is generally interested in a topic might follow the links that pique his curiosity, without worrying too much about getting lost. But faced with a specific question and a set of properties and values to which the query maps reasonably well, the user may be better off not using the links.

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